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Human interaction with policy flight simulators

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ABSTRACT

Policy flight simulators are designed for the purpose of exploring alternative management policies at levels ranging from individual organizations to national strategy. This article focuses on how such simulators are developed and on the nature of how people interact with these simulators. These interactions almost always involve groups of people rather than individuals, often with different stakeholders in conflict about priorities and courses of action. The ways in which these interactions are framed and conducted are discussed, as well as the nature of typical results.

1. Introduction

The human factors and ergonomics of flight simulators have long been studied in terms of the impacts of simulator fidelity, simulator sickness, and so on. Much has been learned about humans' visual and vestibular systems, leading to basic insights into human behavior and performance. This research has also led to simulator design improvements.

More recently, the flight simulator concept has been invoked to capture the essence of how interactive organizational simulations can be used to "fly the future before you write the check." The idea is for organizational leaders to be able to interactively explore alternative organizational designs computationally rather than physically. Such explorations allow rapid consideration of many alternatives, perhaps as a key step in developing a vision for transforming an enterprise.

Computational modeling of organizations has a rich history in terms of both research and practice (Prietula et al., 1998; Carley, 2002; Rouse and Boff, 2005). This approach has achieved credibility in organization science (Burton, 2003; Burton and Obel, 2011). It is also commonly used by the military.

Simulation of physics-based systems has long been in common use, but the simulation of behavioral and social phenomena has only matured in the past decade or so. It is of particular value for exploring alternative organizational concepts that do not yet exist and, hence, cannot be explored empirically. The transformation of health delivery is, for example, a prime candidate for exploration via organizational simulation (Basole et al., in press).

This article focuses on the nature of how people interact with flight simulators that are designed for the purpose of exploring alternative management policies at levels ranging from individual organizations to national strategy. Often, the organizations of interest are best characterized as complex adaptive systems, and modeled using multi-level representations. The interactions with simulators of such complex systems almost always involve groups of people rather than individuals, often with different stakeholders in conflict about priorities and courses of action. In this article, the ways in which these interactions are framed and conducted are discussed, as well as the nature of typical results.

2. Complex adaptive systems

Many people attempt to think about organizational systems in terms of exemplars ranging from vehicles (e.g., airplanes), to process plants (e.g., utilities), to infrastructure (e.g., airports), to enterprises (e.g., Wal-Mart). They often think in terms of decomposing the overall problem of system performance and management into component elements (e.g., propulsion, suspension, electronics, etc.) and, subsequently recomposing the designed solution for each element into an overall system design.

This approach to hierarchical decomposition (Rouse, 2003) has worked well to provide us automobiles, highways, laptops, cell phones, and the ability to buy products from anywhere in the world at attractive prices. Success, however, has depended on the ability to decompose and recompose the elements of the system and, of particular importance, the authority and resources to accomplish this work.

Not all system design and management problems can be addressed this way. One problem is that the decomposition may result in losing important information resulting from interactions among the phenomena of interest. Another very fundamental problem is that there may be no one "in charge," with the authority and resources to pursue this work. Complex adaptive systems

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represent a class of design and management problems that tend to have these limitations.[1]

Complex adaptive systems can be defined in terms of their characteristics (Rouse, 2000, 2008):

- They are *nonlinear, dynamic* and do not inherently reach fixed equilibrium points. The resulting system behaviors may appear to be random or chaotic.
- They are composed of *independent agents* whose behavior can be described as based on physical, psychological, or social rules, rather than being completely dictated by the dynamics of the system.
- Agents' needs or desires, reflected in their rules, are not homogenous and, therefore, their *goals and behaviors are likely to conflict* – these conflicts or competitions tend to lead agents to adapt to each other's behaviors.
- Agents are *intelligent, and learn* as they experiment and gain experience, and change behaviors accordingly. Thus, overall systems behavior inherently changes over time.
- Adaptation and learning tends to result in *self-organizing* and patterns of behavior that emerge rather than being designed into the system. The nature of such emergent behaviors may range from valuable innovations to unfortunate accidents.
- There is *no single point(s) of control* – systems behaviors are often unpredictable and uncontrollable, and no one is "in charge." Consequently, the behaviors of complex adaptive systems usually can be influenced more than they can be controlled.

There are important implications for transforming organizational systems that have these characteristics. One cannot, using any conventional means, command or force such systems to comply with behavioral and performance dictates. The agents in such systems are sufficiently intelligent to game the system, find workarounds, and creatively identify ways to serve their own interests, e.g., their mandated or perceived entitlements.

Two overarching competencies enable leading successful transformation of enterprises – vision and leadership (Rouse, 2011). In complex adaptive systems, however, the leader cannot impose the vision of the transformed enterprise. This article shows how policy flight simulators can allow key stakeholders to "drive the future" before they commit to it. While there is a range of implementation challenges that follow such commitments (Rouse, 1996, 2001, 2006), especially the risk of being derailed by organizations delusions (Rouse, 1998a), this paper focuses solely on elaboration and exploration of alternative visions of the transformed enterprise.

3. Multi-level modeling

To develop policy flight simulators, we need to computationally model the functioning of the complex adaptive system of interest to enable decision makers, as well as other significant stakeholders, to explore the possibilities and implications of transforming these enterprise systems in fundamental ways. The goal is to create organizational simulations that will serve as policy flight simulators for interactive exploration by teams of often disparate stakeholders who have inherent conflicts, but need and desire an agreed upon way forward (Rouse and Boff, 2005).

[1] In recent years, such systems have also been characterized as "systems of systems," particularly by those associated with the U.S. Department of Defense. This concept, as originally framed by Ackoff (1971), certainly has its merits.

Consider the architecture of public-private enterprises shown in Fig. 1 (Rouse, 2009; Rouse and Cortese, 2010; Grossman et al., 2011). The efficiencies that can be gained at the lowest level (work practices) are limited by nature of the next level (delivery operations). Work can only be accomplished within the capacities provided by available processes. Further, delivery organized around processes tends to result in much more efficient work practices than for functionally organized business operations.

However, the efficiencies that can be gained from improved operations are limited by the nature of the level above, i.e., system structure. Functional operations are often driven by organizations structured around these functions, e.g., manufacturing and service. Each of these organizations may be a different business with independent economic objectives. This may significantly hinder process-oriented thinking.

And, of course, potential efficiencies in system structure are limited by the ecosystem in which these organizations operate. Market maturity, economic conditions, and government regulations will affect the capacities (processes) that businesses (organizations) are willing to invest in to enable work practices (people), whether these people be employees, customers, or constituencies in general. Economic considerations play a major role at this level (Rouse, 2010a,b).

These organizational realities have long been recognized by researchers in socio-technical systems (Emery and Trist, 1973), as well as work design and system ergonomics (Hendrick and Kleiner, 2001). The contribution of the research reported in this article is the enablement of computational explorations of these realities, especially by stakeholders without deep disciplinary expertise in these phenomena.

4. Example policy flight simulator

Developing multi-level models of large-scale public-private enterprises is a challenge in itself. Getting decision makers and other stakeholders to employ these models to inform their discussions and decisions is yet a greater challenge. We have found that interactive simulation models can provide the means to meeting this challenge. The decision makers with whom we have

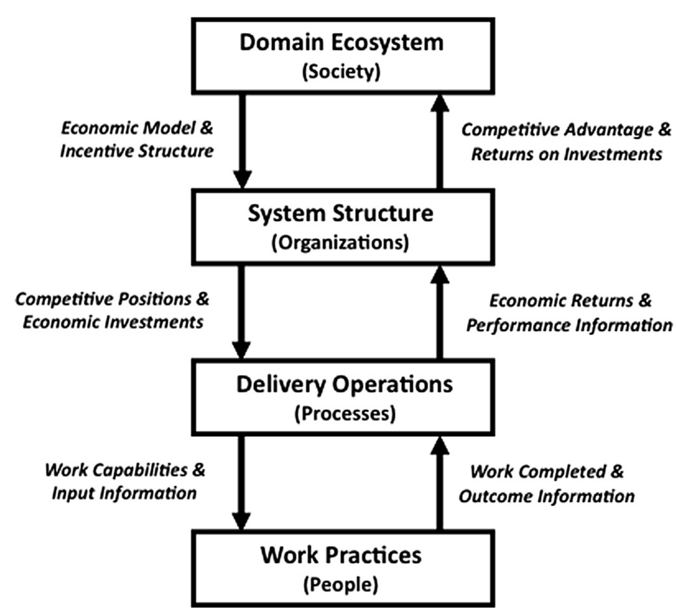

Fig. 1. Architecture of public private enterprises.

worked have found that the phrase “policy flight simulator” makes sense to them.

Multi-level simulations can provide the means to explore a wide range of possibilities, thereby enabling the early discarding of bad ideas and refinement of good ones. This enables driving the future before writing the check. One would never develop and deploy an airplane without first simulating its behavior and performance. However, this happens all too often in enterprise systems in terms of policies, strategies, plans, and management practices that are rolled out with little, if any, consideration of higher-order and unintended consequences.

This policy flight simulator focused on the Predictive Health Institute (PHI), a joint initiative of Emory University and Georgia Institute of Technology (Brigham, 2010; Rask et al., 2011). PHI is a health-focused facility that counsels essentially healthy people on diet, weight, activity, and stress management. The multi-level model focused on the roughly 700 people in PHI’s cohort and their risks of type 2 diabetes (DM) and coronary heart disease (CHD). We calculated every person’s risk of each disease using well accepted risk models based on national data sets (Wilson et al., 1998, 2007), using PHI’s initial individual assessments of blood pressure, fasting glucose level, etc. for each participant. Subsequent assessment data were used to estimate annual risk changes as a function of initial risks of each disease.

The four-level model of Fig. 1 was implemented as a multi-level simulation. Separate displays were created to portray the operation of each level of the model. Runs of the multi-level simulation were set up using the dashboard in Fig. 2. The top section of the dashboard allows decision makers to test different combinations of policies from the perspective of Human Resources (HR). For instance, this level determines the allocation of payment to PHI based on a hybrid capitated or pay-for-outcome formula. It also involves choices of parameters such as projected healthcare inflation rate, general economy inflation rate, and discount rate that affect the economic valuation of the outcomes of PHI’s prevention and wellness program. One of the greatest concerns of HR is achieving a satisfactory Return on Investment (ROI) on any investments in prevention and wellness.

Note that the notion of payer is different in the U.S. than in most other developed countries. The payer for the majority of people covered by health insurance in the U.S. is their employer. Payment is usually managed by the HR function in companies, often with assistance from the private insurance company that administers the company’s plan. Companies are almost always concerned that healthcare expenditures are well managed and provide “returns” in terms of the well being of employees and their families, as well as the performance of employees in their jobs (Rouse, 2010b).

The concerns of PHI are represented in the lower section of the dashboard. These concerns include the organization’s economic sustainability – their revenue must be equal to or greater than their costs. To achieve sustainability, PHI must appropriately design its operational processes and rules. Two issues are central. What risk levels should be used to stratify the participant population? What assessment and coaching processes should be employed for each strata of the population? Other considerations at this level include the growth rate of the participant population, the age ranges targeted for growth, and the program duration before participants are moved to “maintenance.”

Decision makers can also decide what data source to employ to parameterize the models – either data from the American Diabetes Association (ADA) and American Heart Association (AHA), or data specific to Emory employees. Decision makers can choose to only count savings until age 65 or also project post-retirement savings.

This policy flight simulator was used to explore two scenarios: 1) capitated payment for services and, 2) payment for outcomes. Hybrids of these scenarios were also investigated (Park et al., 2012).

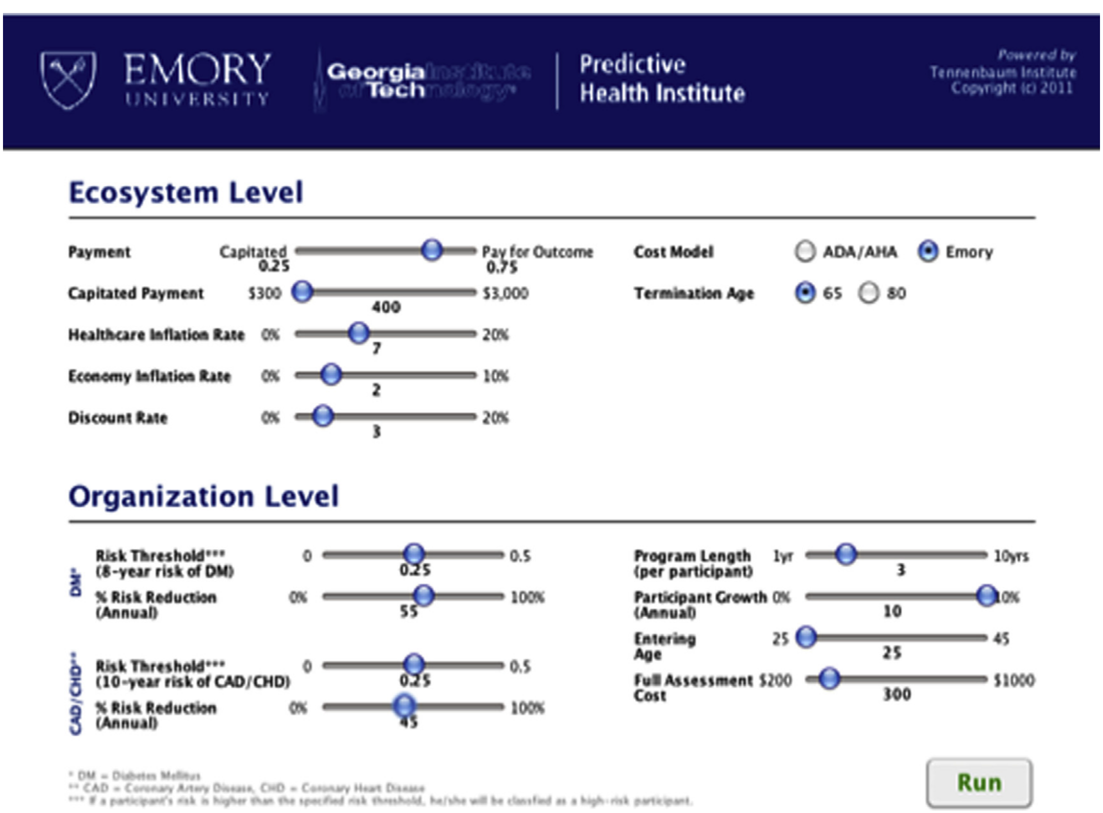

Fig. 2. Simulator dashboard for prevention and wellness.

The goal was to understand the influence of capitation and pay-for-outcome levels on economic outcomes for both payer (HR) and provider (PHI). Fig. 3 illustrates the effects of these two variables. Since PHI delivers the same service to all volunteers, a pure capitated payment is essentially a fee for service. PHI can be very profitable if the capitated payment is sufficiently large. On the other hand, PHI does only modestly well by comparison under a payment for outcomes system, in large part because it's population is not pre-screened for people at risk.

Emory HR's results are virtually opposite, although it can still do relatively well under the right blend of capitation and pay for outcome. Fig. 3 presents the aggregate results for Emory as a whole and, in some sense, is a surrogate for "society" and its overall gain under various health care payment systems. Here the results are far less intuitive and, in fact, a typical negotiation that finds middle ground, e.g., by splitting the difference between HR and PHI, would not achieve anything close to the maximum potential overall societal gain.

In other words, when we compromise between the returns to HR and PHI, the aggregate returns to Emory are minimized. The best economic results are achieved when *either* PHI's profit is maximized or Emory HR's ROI is maximized. There are a variety of reasons why one might choose either extreme. However, another possibility emerged from discussions while using the policy flight simulator.

HR could maximize its ROI while providing PHI a very lean budget. At the end of each year, HR could then provide PHI with a bonus for the actual savings experienced that year. This could be determined by comparing the projected costs for the people in the program to their actual costs of health care, absenteeism and presenteeism. In this way, HR would be sharing actual savings rather than projected savings. The annual bonuses would free PHI of the fear of not being sustainable, although PHI would need to substantially reorganize its delivery system to stratify participants by risk levels and tailor processes to each stratum.

This policy flight simulator was used to explore a wide range of other issues such as the best levels of participant risk stratification and the impacts of inflation and discount rates. The key insight for PHI management was that they needed to redesign their processes and decision rules if they were going to provide a good return to HR and stay in business. They learned how best to redesign their offerings using the policy flight simulator. Now they are getting ready for flight tests.

5. People's use of simulators

There are eight tasks associated with creating and using policy flight simulators:

- Agreeing on objectives – the questions – for which the simulator will be constructed.
- Formulating the multi-level model – the engine for the simulator – including alternative representations and approaches to parameterization.
- Designing a human–computer interface that includes rich visualizations and associated controls for specifying scenarios.
- Iteratively developing, testing and debugging, including identifying faulty thinking in formulating the model.
- Interactively exploring the impacts of ranges of parameters and consequences of various scenarios.
- Agreeing on rules for eliminating solutions that do not make sense for one or more stakeholders.
- Defining the parameter surfaces of interest and "production" runs to map these surfaces.
- Agreeing on feasible solutions and the relative merits and benefits of each feasible solution.

The discussions associated with performing the above tasks tend to be quite rich. Initial interactions focus on agreeing on objectives, which includes output measures of interest, including units of measure. This often unearths differing perspectives among stakeholders.

Attention then moves to discussions of the phenomena affecting the measures of interest, including relationships among phenomena. Component models are needed for these phenomena and agreeing on suitable vetted, and hopefully off-the-shelf, models

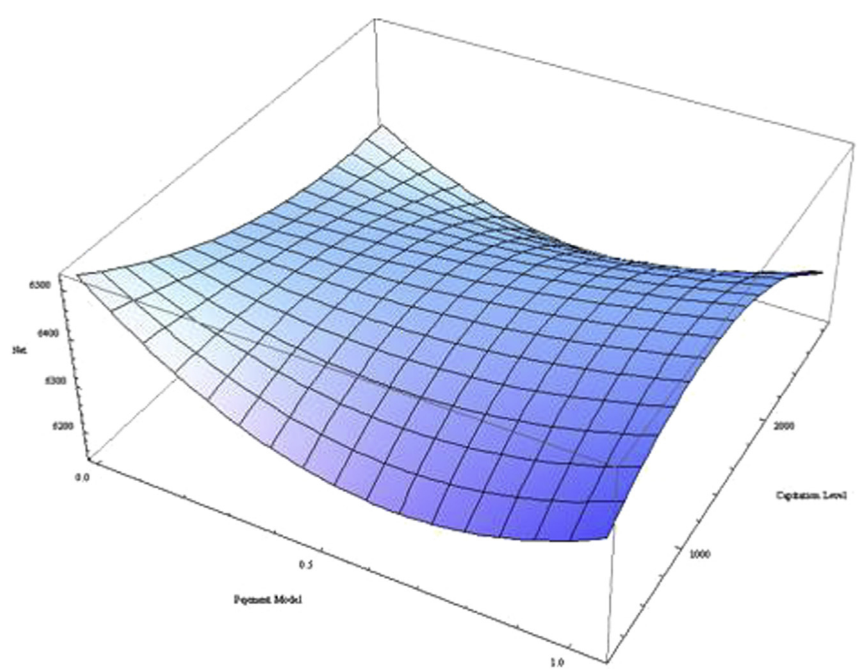

Fig. 3. Net economic value as a function of payment model.

occurs at this time. Also of great importance are uncertainties associated with these phenomena, including both structural and parametric uncertainties.

As computational versions of models are developed and demonstrated, discussions center on the extent to which model responses are aligned with expectations. The overall goal is to computationally redesign the enterprise. However, the initial goal is usually to replicate the existing organization to see if the model predicts the results actually being currently achieved.

Once attention shifts to redesign, discussion inevitably shifts to the question of how to validate the model's predictions. As these predictions inherently concern organizational systems that do not yet exist, validation is limited to discussing the believability of the insights emerging from debates about the nature and causes of model outputs. In some cases, deficiencies of the models will be uncovered, but occasionally unexpected higher-order and unintended consequences make complete sense and become issues of serious discussion.

Model-based policy flight simulators are often used to explore a wide range of ideas. It is quite common for one or more stakeholders to have bright ideas that have substantially negative consequences. People typically tee up many alternative organizational designs, interactively explore their consequences, and develop criteria for the goodness of an idea. A common criterion is that no major stakeholder can lose in a substantial way. For the Emory simulator, this rule pared the feasible set from hundreds of thousands of configurations to a few hundred.

Quite often, people discover the key variables most affecting the measures of primary interest. They then can use the simulator in a "production mode," without the graphical user interface, to rapidly simulate ranges of variables to produce surface plots such as shown in Fig. 3. The simulator runs to create this plot were done without the user interface of Fig. 2.

Discussions of such surface plots, as well as other results, provide the basis for agreeing on pilot tests of apparently good ideas. Such tests are used to empirically confirm the simulator's predictions, much as flight tests are used to confirm that an aircraft's performance is similar to that predicted when the plane was designed "in silico."

Policy flight simulators serve as boundary spanning mechanisms, across domains, disciplines and beyond initial problem formulations, which are all too often more tightly bounded than warranted. Such boundary spanning results in arguments among stakeholders being externalized. The alternative perspectives are represented by the assumptions underlying and the elements that compose the graphically depicted model projected on the large screen. The debate then focuses on the screen rather than being an argument between two or more people across a table.

The observations in this section are well aligned with Rouse's (1998b) findings concerning what teams seek from computer-based tools for planning and design:

- Teams want a clear and straightforward process to guide their decisions and discussions, with a clear mandate to depart from this process whenever they choose.
- Teams want capture of information compiled, decisions made, and linkages between these inputs and outputs so that they can communicate and justify their decisions, as well as reconstruct decision processes.
- Teams want computer-aided facilitation of group processes via management of the nominal decision making process using computer-based tools and large screen displays.
- Teams want tools that digest the information that they input, see patterns or trends, and then provide advice or guidance that the group perceives they would not have thought of without the tools.

Policy flight simulators do not yet fully satisfy all these objectives, but they are headed in this direction.

It is useful to note that the process outlined in this section is inherently a participatory design process (Schuler and Namioka, 1993). This human-centered process considers and balances all stakeholders' concerns, values and perceptions (Rouse, 2007). The result is a better solution and, just as important, an acceptable solution.

6. Conclusions

This article has discussed policy flight simulators that are designed for the purpose of exploring alternative management policies at levels ranging from individual organizations to national strategy. The focus was on both how such simulators are developed and on the nature of how people interact with these simulators. These interactions almost always involve groups of people rather than individuals, often with different stakeholders in conflict about priorities and courses of action. The ways in which these interactions are framed and conducted were discussed, as well as the nature of typical results.

Current policy fight simulator projects include:

- Chronic disease management at Vanderbilt University Medical Center – the focus is on scaling this successful program to millions of participants.
- Secure communications for the Department of Defense – the focus in on alternative polices and technology strategies for securing communications.
- Counterfeit parts in electronics and semiconductor supply chains – the focus is on both interdicting the intention to counterfeit and understand the operational implications of counterfeit parts being deployed in systems.

All of these projects are pursuing the eight tasks elaborated earlier and involve the types of discussions and debates outlined above.

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